ATTACHMENT 6

2. Exposure Scenarios

TWFs were generated for five exposure scenarios selected to represent the range of activities undertaken during the various simulation studies.

Scenario 1: *Moving/storing/cleaning boxes in VAI attic space*

This scenario is assumed to apply only to residents, because some of the contractor simulations include moving boxes as a part of another activity. It is assumed that the exposure duration for this scenario is a 0.5 hour (typical) and 1 hour (high-end) per event.

Scenario 2: *Small area clearance / wiring / moving aside VAI*

This scenario involves activities including removal and clearance of a small area of VAI, as might be done to provide access and repair to electrical wires and junction boxes and for minor renovations. This activity typically also includes replacement of VAI after the work is done and is assumed to take between 0.5 and 1.5 hours.

Scenario 3: *Small area clearance and fan installation.*

This scenario is similar to Scenario 2, but includes drilling a hole from below prior to clearance of VAI from the ceiling space above and installation of a ceiling fan with associated electrical wiring. This activity is assumed to take between 3 and 5 hours.

Scenario 4: *Large area clearance and refill.*

In this scenario, a large area of VAI is disturbed or moved aside, for example, in preparation for installation of attic space equipment or a skylight. This activity is assumed to take between 1 and 2 hours.

Scenario 5: *Removal of VAI.*

This scenario includes the removal of VAI for replacement with another type of insulation. The activities include scooping, bagging and sweeping activities. This activity is assumed to take between 8 and 12 hours.

Table V-1 shows how the various activities, as described in the simulation studies, were grouped under the scenario designations. This table is not necessarily meant to imply similarities in the activities for which differences are reflected in the air concentration data; rather the grouping allows for use of set standardized TWFs for consistent evaluation of the data and consistency in the risk estimates. In other words, for this risk assessment, the activities in the same scenario group are assumed to take up the same amount of a person's time.

Table V-1. Summary of VAI Disturbance Scenarios Matched to Activities Simulated in the Exposure Studies

Scenario	Lees and Mlynarek (2003)	Versar (2002)	Claimants' Washington State Study
1	Moving boxes	Using the attic with vermiculite insulation as a storage space	Cleaning stored items
2	Small area clearance	Wiring or small renovation in an attic containing dry vermiculite	Shop Vac removal of VAI from top perimeter wall cavities
3	Small area clearance with ceiling fan installation		Ceiling penetration
4	Large area clearance		Moving aside VAI (Grace method[5]/ homeowner method)
5		Removing vermiculite attic insulation	

[5] The claimants refer to the "Grace method," but it is not clear why it is given that name. Nonetheless, we have used their characterization in this report so that it is clear to which scenario in the claimants' study we are referring to.

3. <u>Duration of Exposure (years)</u>

Residents

For activities that can be expected to occur regularly, i.e., on annual basis, the years of exposure are based on the average and upper bound home tenures derived from population mobility studies. The average tenure in a home, 9 years, is assumed for the typically exposed resident, and the 90th percentile value, 30 years, is used for a high-end exposed resident (EPA, 1997).

Contractors

Contractors' exposure durations are reflective of occupational tenure. The exposure duration for typical contractors has been assumed to be 11 years. This value is approximately the same as the median occupational tenure for electricians, a profession with high occupational tenure relative to other contractors (Carey, 1988). The high end value is 45 years based on the assumption that an individual commences work at 20 years old and works as a contractor until 65 years of age.

4. <u>Time Weighting Factors</u>

The following summarizes the TWFs and discusses the important assumptions that were made in deriving the TWFs. The combination of time spent in an activity, exposure frequency and exposure duration is best described by the number of hours spent in a scenario during an individual's lifetime.

Residents

The amount of time that is assumed to be spent by typical and high-end exposed residents that are engaged in VAI disturbing activities and the corresponding TWFs (expressed as a percentage of a lifetime) are shown in Table V-2. These estimates include the potential for a homeowner to engage in home renovation activities that may disturb VAI.

Table V-2. Summary of Estimated Exposure Durations and TWFs for Residents

Activity	Scenario	Time Spent in Activity (hrs/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Total Events	Total Hours	Time Weighting Factor (%)
1 / Moving boxes	Typical	0.5	2	9	18	9	0.0015%
	High-end	1	4	30	120	120	0.020%
2 / Small area clearance	Typical	0.5	1	2	2	1	0.00016%
	High-end	1.5	1	5	5	8	0.0012%
3 / Small area clearance & fan installation	Typical	3	1	1	1	3	0.00049%
	High-end	5	1	2	2	10	0.0016%
4 / Large area clearance	Typical	1	1	1	1	1	0.00016%
	High-end	2	1	2	2	4	0.00065%
5 / Removing VAI	Typical	8	1	1	1	8	0.0013%
	High-end	12	1	1	1	12	0.0020%

Contractors

In this assessment, contractors are assumed to undertake the same activities as residents and take the same amount of time to complete the activity, but the frequency of exposure is assumed to be higher. Unlike residents, who are assumed to live in VAI-containing homes, a contractor will work in numerous homes during their working life. Therefore, the frequency of working in a VAI home and the probability that the contractor will undertake an activity that brings them into contact with VAI within a VAI home are important considerations.

It has been estimated that there may be about 940,000 homes in the U.S. with VAI (Versar, 1982), of the approximately 81 million homes in the U.S. (USDOC 1996)[6]. These data imply a frequency of VAI homes in the U.S. of about 1.16%. However, the frequency may be higher in colder climates. Therefore, for the upper-bound exposure scenarios, a 3.0% frequency of VAI homes was assumed, or nearly triple that national average. Using this information and the standard assumption of 250 working days per year, a contractor can be expected to spend, on average, 2.9 days per year in a VAI home, and 7.5 days as the high-end.

There are not specific data to indicate how frequently a contractor's work may include the disturbance of VAI. However, there are many activities that contractors perform in and around homes that do not require entrance to or significant time in the attic. Therefore, if a contactor enters a home with VAI, a value of 10% was assumed for the probability that a contractor would engage in an activity that would disturb the VAI. These assumptions may be very conservative.

Therefore, the number of days per year that a contractor may enter a home with VAI and engage in an activity that results in a disturbance of the VAI is estimated as follows:

$$\textit{VAI Contact (days/yr)} = \textit{Work Days} * \textit{Prob(VAI-home)} * \textit{Prob(VAI-activity)} \quad \text{(V-3)}$$

where:

Work Days = Total number of working days per year for a contractor

[6] The value represents census data from 1993 for the flowing home categories: "single family detached", "single family attached" and "2 to 4 units". It is conservatively assumed that a residential contractor does not work in buildings with larger numbers of units, which, in any event, are not likely to contain VAI.

Prob(VAI-home) = probability that a particular home will have VAI (1.16% for typical and 3.0% for high-end)
Prob(VAI-activity) = probability that a contractor will engage in an activity that might disturb the VAI (10%)

Applying equation V-3, the exposure frequencies for activities involving disturbance of VAI for the typical and high-end contractor are 0.29 days per year and 0.75 days per year, respectively. The details of this calculation are shown in Table V-3.

Table V-3. Summary of the Derivation of Exposure Durations for Contractors

Exposure Factor	Typical Scenario	High-End Scenario	Note
Homes with VAI	940,000	940,000	Versar (1982)
Total Homes	81,094,000	81,094,000	US DOC (1996)[a]
Frequency of VAI homes	1.16%	3.0%	calculated/assumed
Working days / year	250	250	assumed
Days working in VAI home / year	2.9	5.0	calculated[b]
Probability of Contact with VAI in VAI home	10%	10%	assumed
Days contacting VAI / year	0.29	0.75	calculated

[a] The value used represents the sum of homes in the following categories: "single family detached" (64,283,000 units), "single family attached" (6,079,000 units) and "2 to 4 units" (10,732,000 units).
[b] The VAI-home EF is the frequency of VAI homes multiplied by the number of working days per year.

The hours spent engaged in activities involving contact with VAI by typical and high-end exposed contractors and the corresponding TWFs (expressed as a percentage of a lifetime) are summarized in Table V-4.

Table V-2. Summary of Estimated Exposure Durations and TWFs for a Contractor

Activity	Scenario	Time Spent in Activity (hrs/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Total Events	Total Hours	Time Weighting Factor (%)
2 / Small area clearance	Typical	0.5	0.29	11	3	2	0.00026%
	High-end	1.5	0.75	45	34	51	0.0083%
3 / Small area clearance & fan installation	Typical	3	0.29	11	3	10	0.0016%
	High-end	5	0.75	45	34	169	0.028%
4 / Large area clearance	Typical	1	0.29	11	3	3	0.00052%
	High-end	2	0.75	45	34	68	0.011%
5 / Removing VAI	Typical	8	0.29	11	3	26	0.0042%
	High-end	12	0.75	45	34	405	0.066%

B. *Using the exposure duration assumptions, lifetime average exposure estimates can be developed for residents and contractors with the personal exposure data that is useful for risk assessment. Cancer risks can be estimated for each exposure estimate using the recommended EPA dose-response model for asbestos.*

The risk estimates are summarized in Tables V-5 through V-8. The tables contain the following:

- *Table V-5*: risks for residents for asbestiform fibers
- *Table V-6*: risks for contractors for asbestiform fibers
- *Table V-7*: risks for residents for asbestiform fibers plus cleavage fragments
- *Table V-8*: for contractors for asbestiform fibers plus cleavage fragments

Tables V-5 and V-6 include risk estimates for the Lees and Mlynarek and Claimants-Washington studies. Because the EPA/Versar study likely includes cleavage fragments, it was not included in the tables for asbestiform fibers only. Table V-7 and V-8 includes risks for Lees and Mlynarek, Claimants-Washington, and Versar/EPA. However, because cleavage fragments are not classified as carcinogenic and not counted under EPA/IRIS and OSHA, the risks in these tables are overestimates of the actual risk. Appendix D contains detailed tables showing all of the fiber concentrations from each study and scenario, the corresponding TWFs, and the estimated risks.

When appropriate data were available, risks were calculated for the workers engaged in the activities, any helper in the vicinity of the activity, and a bystander who may have been in the home but not in the attic during the disturbance. For each scenario and type of exposed individual, a typical and high-end exposure was estimated.

When there were no fibers detected for a particular sample, a value of zero was used (Oehlert et al., 1995), consistent with the procedures used by EPA/Versar and by EPA Region VIII in its assessments in Libby. For the typical residential scenarios, an average count was used to estimate risk when there were multiple samples. For the high-end residential scenario, the maximum fiber count was used to estimate risk. For contractors, the average fiber counts were used for the typical and high-end scenarios, reflecting that the contractor would likely be

exposed to average concentrations over time by conducting activities in various homes.

Risks were estimated for the separate activities in the studies (i.e., moving boxes, small area clearance, etc.). Additionally, the aggregate risk of all these activities (i.e., the combined risk) was also calculated. This estimate is conservative because it assumes that the resident engages in all of these activities on separate occasions. By calculating an aggregate risk, I have essentially increased the exposure frequencies derived in Table V-3.

Table V-5. Estimated Plausible Upper-Bound Risks for Residents for Asbestos and Asbestiform Fibers

Activity	Residents					
	Worker		Helper		Bystander	
	Typical	High End	Typical	High End	Typical	High End
Based on Lees and Mlynarek						
Moving Boxes	1.7E-09	1.4E-07	0	0	0	0
Small Area Clearance	3.7E-08	5.8E-07	2.7E-09	8.2E-08	0	0
Small Area Clearance & Fan Installation	0	0	0	0	0	0
Large Area Clearance	6.2E-09	6.2E-08	1.1E-09	5.6E-09	0	0
Aggregate Risk	**4.5E-08**	**7.8E-07**	**3.8E-09**	**8.7E-08**	**0**	**0**
Based on Claimants' Washington State Study						
Cleaning Stored Items	0	0	0	0	--	--
Ceiling Penetration	5.6E-08	1.9E-07	1.3E-07	4.3E-07	--	--
Moving Aside VAI - Grace Method	2.0E-07	7.8E-07	0	0	--	--
Moving Aside VAI - Homeowner Method	2.1E-07	8.5E-07	3.6E-08	1.4E-07	--	--
Shop Vac Removal VAI from Top Perimeter Wall Cavities	0	0	2.7E-08	2.0E-07	--	--
Aggregate Risk*	**2.7E-07**	**1.0E-06**	**1.9E-07**	**7.7E-07**	**--**	**--**

Plausible upper-bound means the risk could be considerably lower, even approaching zero.
* Total does not include risk from "Moving Aside - Grace Method," because the higher exposure scenario "Moving Aside VAI – Homeowner Method" was included in the total.

Table V-6. Estimated Plausible Upper-Bound Risks for Contractors for Asbestos and Asbestiform Fibers

Activity	Contractors					
	Worker		Helper		Bystander	
	Typical	High End	Typical	High End	Typical	High End
Based on Lees and Mlynarek						
Moving Boxes	--	--	--	--	--	--
Small Area Clearance	5.9E-08	1.9E-06	4.3E-09	1.4E-07	0	0
Small Area Clearance & Fan Installation	0	0	0	0	0	0
Large Area Clearance	2.0E-08	4.2E-07	3.5E-09	7.4E-08	0	0
Aggregate Risk	**7.9E-08**	**2.3E-06**	**7.8E-09**	**2.1E-07**	**0**	**0**
Based on Claimants' Washington State Study						
Cleaning Stored Items	--	--	--	--	--	--
Ceiling Penetration	1.8E-07	3.2E-06	4.1E-07	7.2E-06	--	--
Moving Aside VAI - Grace Method	6.2E-07	1.3E-05	0	0	--	--
Moving Aside VAI - Homeowner Method	6.8E-07	1.4E-05	1.1E-07	2.4E-06	--	--
Shop Vac Removal VAI from Top Perimeter Wall Cavities	0	0	4.3E-08	1.4E-06	--	--
Aggregate Risk*	**8.6E-07**	**1.8E-05**	**5.7E-07**	**1.1E-05**	**--**	**--**

Plausible upper-bound means the risk could be considerably lower, even approaching zero.
* Total does not include risk from "Moving Aside - Grace Method," because the higher exposure scenario "Moving Aside VAI – Homeowner Method" was included in the total.

Table V-7. Bounding Estimates of Risks for Residents for Asbestiform Fibers and Cleavage Fragments

Activity	Residents					
	Worker		Helper		Bystander	
	Typical	High End	Typical	High End	Typical	High End
Based on Lees and Mlynarek						
Moving Boxes	1.3E-07	6.1E-06	0	0	2.6E-09	2.1E-07
Small Area Clearance	2.2E-07	1.9E-06	1.1E-08	2.0E-07	0	0
Small Area Clearance & Fan Installation	2.5E-07	8.9E-07	8.9E-10	5.9E-09	0	0
Large Area Clearance	7.9E-08	5.4E-07	1.1E-08	6.8E-08	2.5E-10	6.0E-09
Aggregate Risk	**6.8E-07**	**9.4E-06**	**2.3E-08**	**2.7E-07**	**2.8E-09**	**2.1E-07**
Based on Claimants' Washington State Study						
Cleaning Stored Items	0	0	0	0	--	--
Ceiling Penetration	6.1E-07	2.0E-06	7.7E-07	2.6E-06	--	--
Moving Aside VAI - Grace Method	1.7E-06	6.7E-06	0	0	--	--
Moving Aside VAI - Homeowner Method	3.6E-06	1.4E-05	6.6E-07	2.6E-06	--	--
Shop Vac Removal VAI from Top Perimeter Wall Cavities	2.6E-07	1.9E-06	8.1E-08	6.1E-07	--	--
Aggregate Risk*	**4.5E-06**	**1.8E-05**	**1.5E-06**	**5.8E-06**	--	--
Based on Versar/EPA						
Using the Attic with Vermiculite Insulation as a Storage Space	4.3E-07	1.1E-05	--	--	--	--
Wiring or Small Renovation in an Attic Containing Dry Vermiculite	5.5E-07	7.4E-06	--	--	--	--
Removing Vermiculite Attic Insulation	9.2E-07	1.8E-06	--	--	--	--
Aggregate Risk	**1.9E-06**	**2.0E-05**	--	--	--	--

These estimates are upper-end bounding estimates that overestimate the actual risk because cleavage fragments should not be assigned the potency presented in the IRIS file to asbestiform fibers. For example, EPA has recommended that cleavage fragments should not be included when developing risk estimates with the IRIS potency factor (Lioy et al., 2002).

* Total does not include risk from "Moving Aside - Grace Method," because the higher exposure scenario "Moving Aside VAI – Homeowner Method" was included in the total.

Table V-8. Bounding Estimates of Risks for Contractors for Asbestiform Fibers and Cleavage Fragments

Activity	Contractors					
	Worker		Helper		Bystander	
	Typical	High End	Typical	High End	Typical	High End
Based on Lees and Mlynarek						
Moving Boxes	--	--	--	--	--	--
Small Area Clearance	3.5E-07	1.1E-05	1.8E-08	5.7E-07	0	0
Small Area Clearance & Fan Installation	8.0E-07	1.4E-05	2.8E-09	5.0E-08	0	0
Large Area Clearance	2.5E-07	5.3E-06	3.4E-08	7.3E-07	8.0E-10	1.7E-08
Aggregate Risk	**1.4E-06**	**3.1E-05**	**5.5E-08**	**1.3E-06**	**8.0E-10**	**1.7E-08**
Based on Claimants' Washington State Study						
Cleaning Stored Items	--	--	--	--	--	--
Ceiling Penetration	1.9E-06	3.4E-05	2.4E-06	4.3E-05	--	--
Moving Aside VAI - Grace Method	5.4E-06	1.1E-04	0	0	--	--
Moving Aside VAI - Homeowner Method	1.1E-05	2.4E-04	2.1E-06	4.4E-05	--	--
Shop Vac Removal VAI from Top Perimeter Wall Cavities	4.1E-07	1.3E-05	1.3E-07	4.2E-06	--	--
Aggregate Risk*	**1.4E-05**	**2.9E-04**	**4.7E-06**	**9.2E-05**	--	--
Based on Versar/EPA						
Using the Attic with Vermiculite Insulation as a Storage Space	--	--	--	--	--	--
Wiring or Small Renovation in an Attic Containing Dry Vermiculite	5.2E-06	9.3E-05	--	--	--	--
Removing Vermiculite Attic Insulation	2.9E-06	4.6E-05	--	--	--	--
Aggregate Risk	**8.2E-06**	**1.4E-04**	--	--	--	--

These estimates are upper-end bounding estimates that overestimate the actual risk because cleavage fragments should not be assigned the potency presented in the IRIS file for asbestiform fibers. For example, EPA has recommended that cleavage fragments should not be included when developing risk estimates with the IRIS potency factor (Lioy et al., 2002).

* Total does not include risk from "Moving Aside - Grace Method," because the higher exposure scenario "Moving Aside VAI – Homeowner Method" was included in the total.

1. Lees and Mlynarek

For residents, the plausible upper-bound risks for asbestiform fibers were below 10^{-6} (or one in a million). When including cleavage fragments, the bounding aggregate risk estimate for the high-end worker scenario was 9.4×10^{-6}. However, these risks are overestimated because cleavage fragments do not have the same potency as asbestiform fibers, as was assumed for the bounding estimate, and should not be assigned the IRIS potency value for asbestos. Therefore, all of the risks for residents were well within EPA's risk range of 10^{-4} to 10^{-6}, or below, even including cleavage fragments. Given the conservative assumptions made in the estimates, these risks are not a concern.

For contractors, the plausible upper-end risks for asbestiform fibers were above 10^{-6} for only the high-end worker aggregate exposure scenario (9.4×10^{-6}). Even including cleavage fragments, the risks were not above 10^{-4}. Therefore, these risks are not a significant concern.

2. Claimants-Washington

For residents, the plausible upper-bound risks for asbestiform fibers were at or below 10^{-6} for the typical and upper-end scenarios. When including cleavage fragments, the bounding risks range between 10^{-4} and 10^{-6}. However, these risks are overestimated because cleavage fragments do not have the same potency as asbestiform fibers, as was assumed for the bounding estimate, and should not have been included in the asbestos fiber counts. Therefore, these risks for residents were well within EPA's risk range of 10^{-4} to 10^{-6}, even including cleavage fragments. Given the conservative assumptions made in the estimates, these risks are not a significant concern.

For contractors, the plausible upper-end aggregate risks for asbestiform fibers were between 1.8×10^{-5} (worker) and 2.1×10^{-5} (helper). When including cleavage fragments, the bounding risks exceeded 10^{-4} for the worker, but the typical bounding risk estimates were below 10^{-4}. Given the conservative assumptions for exposure duration that were made to develop these estimates and other conservative assumptions, these risks are not a significant concern. The only estimate exceeding 10^{-4} risk was a bounding estimate which included cleavage fragments. Because cleavage fragments should not be

assigned the IRIS cancer potency, this risk estimate represents an extreme bounding estimate.

3. Versar/EPA

For the residents, the bounding risk estimates are between 10^{-4} and 10^{-6}. For the contractor, the high-end aggregate risk marginally exceeded 10^{-4} (1.4×10^{-4}). The Versar study likely included cleavage fragments in the fiber counts, and may have used indirect preparation techniques. Therefore, given the conservative assumptions made in the estimates, these risks are not significant concerns.

4. Libby/EPA

Specific risk estimates were not developed for the Libby/EPA data because it is not clear what activities each sample represents. However, of the 44 personal samples that used direct preparation, the average asbestiform concentration was 0.0093 fibers/cc and the maximum concentration was 0.15 fibers/cc. Only 4 of 44 samples (9%) had detectable fiber concentrations. When including cleavage fragments, the average concentration was 0.12 fibers/cc, and the maximum concentration 0.77 fibers/cc. Only 17 of 44 samples (39%) had detectable concentrations of either asbestiform or cleavage fragments.

These fiber counts are relatively similar to those measured in the other studies, so the Libby/EPA data do not add anything new to the risk calculations that were performed in this study.

C. *When confronted with uncertainties associated in the assessment of risks, assumptions were made that tend towards overestimating the actual risks. Therefore, the true risks are likely lower than estimated in this report.*

The overall approach of the risk assessment was to develop accurate estimates of typical and upper-end risk, but make conservative assumptions (i.e., towards overestimating risk) when confronted by uncertainties. Table V-9 summarizes some of the key areas of uncertainties in the assessment, including an assessment of the directional impact that the assumptions that were made have on the risk assessment.

One of the major areas of uncertainty is the EPA cancer risk factor. This factor was developed from human epidemiologic studies of people that were exposed to high levels of asbestos over prolonged periods. The conservatism of EPA's potency factor is consistent with EPA's approach of developing conservative, health-protective risk factors for use in regulatory settings. However, it is likely that the risk is lower or even zero at the much lower exposure levels that are associated with VAI. Therefore, the use of the EPA cancer risk factor adds significantly to the conservatism of the assessment.

Another uncertainty in the assessment is the exposure frequency and durations. There are no studies or surveys that cataloged data on how often a resident or contractor may engage in activities that disturb VAI and for how long. Therefore, this assessment makes conservative assumptions regarding exposure durations that tend to overestimate risks.

Risks were calculated for exposure data from several studies. It is important to note that the data that included cleavage fragments represents overestimates of the exposure to asbestiform fibers of the type that are known to cause cancer at high dosages. In particular, the fiber counts in Versar/EPA study likely include cleavage fragments, which limit the applicability of these data to risk estimates as screening level estimates. This means that if the risk estimates are low, as they are, then the actual risks are expected to be even lower. Screening-level estimates are typically used for screening out those risks which may require further study from risks that are low even using high-end conservative data and assumptions, where no further study is necessary.

Table V-9. Summary of Potential Uncertainties in the Risk Assessment

Element of Risk Assessment	Risk Assessment Factor	Description	Directional Impact on Risk Estimates
Exposure Assessment	Exposure Duration Assumptions	For both residents and contractors, typical and upper-bound exposure durations were developed. The upper-bound durations are designed to represent the individuals or contractors that may spend the most time in areas with VAI exposure. Because of the uncertainty in developing these estimates, conservative assumptions were made that would tend to overpredict the likely exposure durations of most individuals.	↑
	Lees and Mlynarek fiber counts	These fiber counts were collected with the most appropriate methods for risk assessment, and are likely the most accurate.	↔
	Versar/EPA fiber counts	The fiber counts did not match the PCME definition. It is not clear if fibers under 0.4 μm in diameter were excluded or if cleavage fragments were included. Also, indirect preparation techniques were apparently used. All these factors would result in an overestimate of fiber counts.	↑
	Claimants-Washington fiber counts	The fiber counts in the claimants' expert report did not match the PCME definition. However, Dr. Lee was able to develop PCME estimates based on the count sheets, but with some uncertainties.	↔

Element of Risk Assessment	Risk Assessment Factor	Description	Directional Impact on Risk Estimates
	Libby/EPA fiber counts	Although Dr. Lee was able to develop PCME estimates from the Libby data, the measurement methods, the circumstances in which the data were collected, and quality control was poor, which creates uncertainties in any risk estimates.	↔
Risk Estimates	EPA/IRIS cancer risk factor	The EPA cancer risk factor is a conservative, upper-bound estimate of risk. The factor assumes a linear, no-threshold model, which means that risks at low doses are assumed to be proportional with dosage to risks at high doses. It is possible that there is a threshold below which there is no risk, or that the risk at lower dosages (such as observed for VAI) is lower than represented by the EPA risk factor.	↑
	Separate risk estimates with cleavage fragments	To be conservative (i.e., tend to overestimate risks), risk estimates were calculated including cleavage fragments, in addition to estimates with only asbestiform fibers. As Dr. Ilgren has certified, cleavage fragments are not carcinogenic. The IRIS risk factors were developed from studies in environments without a significant amount of cleavage fragments, so using the IRIS risk factor with fiber counts that included cleavage fragments will result in an overestimate of risk. The IRIS file for asbestos says that only asbestos and asbestiform fibers should be counted.	↑

Element of Risk Assessment	Risk Assessment Factor	Description	Directional Impact on Risk Estimates
Risk Characterization	Versar/EPA Risk Estimates	The fiber counts in the Versar study are likely overestimates of PCME concentrations, because cleavage fragments may have been included and indirect preparation techniques may have been used. Thus, the risks estimated with these fiber counts are likely to be overestimates. Additionally, the Versar/EPA assessment used the EPA/IRIS cancer risk factor, which may overestimate risk at the exposure levels in the study (see above).	↑

D. There are other studies that provide information on the asbestos risks associated with VAI that show that the risks are low.

1. <u>The Versar/EPA study found that the risks for residents with VAI in their homes are low.</u>

This report presents risk estimates based on the Versar/EPA study data. However, the draft Versar/EPA report also presented risk estimates for residents (but not contractors), using some different exposure duration assumptions than employed in this report. The risks presented in the Versar/EPA report are very low. Most of the risk estimates are below 10^{-6} (or one in a million). There were a handful of risk estimates between 10^{-4} and 10^{-6}, but none above 10^{-4}.

I provided peer review comments on this report (Anderson, 2002) and noted the low risks despite the general tendency in the study to overestimate risks, because of the method used for the fiber counts (discussed in detail earlier) and the some of the exposure duration assumptions.

The highest risk found by Versar/EPA was $1.5\text{x}10^{-5}$ for a person living in a home where minimal vermiculite attic insulation disturbance occurs four times per year. However, I noted in my review that this risk was inappropriately estimated. The intention of the scenario was to estimate the risk to a resident in a living space in the period during a disturbance in the attic from an activity such as moving boxes. However, there were no fibers found in the measurement made in the living space. Therefore, the risk should have appropriately been described as zero. Instead, the study authors used the fiber count result from the attic, thus assuming that the resident lives in the attic, and pointed out that the risk was overestimated. However, as stated in the report, this risk estimate is highly misleading, and would have more appropriately been listed as zero.

2. <u>The ATSDR medical monitoring study in Libby, Montana showed that exposure to VAI was not associated with any health effects.</u>

Further evidence for the low risk associated with vermiculite attic insulation can be found in the medical monitoring study in Libby conducted by the

ATSDR (ATSDR, 2001). In this study, ATSDR conducted chest radiographs and spirometry testing on a subpopulation of Libby residents that included 6,149 current or former residents of Libby and the surrounding area. The study also included a questionnaire about potential exposure pathways for each resident. There were two relevant pathways to this analysis: (1) having vermiculite insulation in homes (termed *Vermins* in study report), and (2) handling vermiculite insulation (termed *Vermhand*).

ATSDR conducted a multivariate logistic regression analysis to determine which exposure pathways were associated with pleural abnormalities (see Table 12 of the ATSDR report). The regression included 18 exposure categories and made statistical adjustments for age, sex, body mass index, cigarette smoking status, years lived in the Libby area, neighborhood environmental concern level, and pulmonary disease or pulmonary surgery. Neither the *Vermins* nor *Vermhand* exposure pathways were statistically significant in the model, indicating that these pathways were not associated with pleural abnormalities of the lung. This means that there was no evidence in the lung tests that exposure to VAI was associated with exposure to asbestos. Therefore, these results provide further evidence that the cancer risks are low.

ATSDR also conducted a similar logistic regression analysis for the restrictive abnormalities identified in the pulmonary function tests. Again, the analysis showed that the *Vermins* and *Vermhand* exposure pathways were not associated with any abnormalities.

Dr. Gary Marsh, a Professor of Biostatistics at University of Pittsburgh Graduate School of Public Health, reviewed the ATSDR study and also found that the study provided no evidence to show that the living in a home containing Zonolite insulation is associated with an elevated health risk (Marsh, 2002).

VI. The asbestos risks associated with exposure to VAI can be characterized relative to appropriate regulatory criteria.

A. Compared to relevant regulatory criteria, the asbestos risks associated with contact with VAI are low and not of significant concern.

The most accurate risk estimates are without cleavage fragments, as recommended by EPA (Lioy et al., 2002). The estimated risks for residents were very low, at or below 10^{-6}, and well within or below EPA's recommended risk range.

For contractors, the risks were higher than residents because the assumed exposure frequency and durations were higher. However, when making reasonable assumptions, the estimated risks were within ranges considered acceptable by EPA, and lower than many other occupational risks. The risks are considerably lower than the risks for workers exposed at the OSHA PEL. For example, at the current PEL, OSHA estimates that a worker exposed for 45 years would have a risk of 3.4 per 1000 (or 3.4×10^{-3}). The risks to workers associated with VAI are much lower.

B. Compared to other risks to which people are routinely exposed, the risks associated with asbestos exposure to VAI are low.

When characterizing risk estimates, it must be understood that risk is a fact of everyday life. As an example, Figure VI-1 displays the lifetime risks of dying from a variety of causes. The risks are highest for heart disease and cancer (all causes) at 18% and 14%, respectively. The upper and lower ends of EPA's acceptable risk range are shown at the right end of the figure. The upper end is at 10^{-4} (or 0.01%) risk and the lower end is at 10^{-6} (or 0.0001%) risk. The risk of dying by being struck by lighting is an example of a risk within EPA's acceptable risk range at 0.002%. However, the risks of dying from a bicycle accident, a fire, drowning, food poisoning, homicide, and others are greater than EPA's upper risk value of 0.01%. These show that people live with and accept greater risks than are considered acceptable for environmental exposures by regulatory authorities such as EPA.

In addition to the risks displayed in Figure IV-1, it is also worth noting that there are many environmental risks that are similar to or higher than the risks estimated for VAI. For example, Figure IV-2 shows the average cancer risks associated

with air pollutants in urban and rural counties estimated from EPA's National Air Toxics Assessment (NATA). The risks range from 10^{-4} to 10^{-5}, and are experienced by most Americans simply by walking outside or breathing air inside their homes that has infiltrated inside from the outdoor air. This is in contrast to the air pollution risk that may exist for residences that live near an industrial facility, which are often even higher.

Another environmental example is the risks associated with carcinogens in drinking water. Table IV-1 displays the risk estimates at the Maximum Contaminant Level (MCL) for five chemicals. The MCL is set by EPA as an acceptable risk level for drinking water. The risks are generally in the 10^{-4} to 10^{-6} range, consistent with EPA's acceptable risk range.

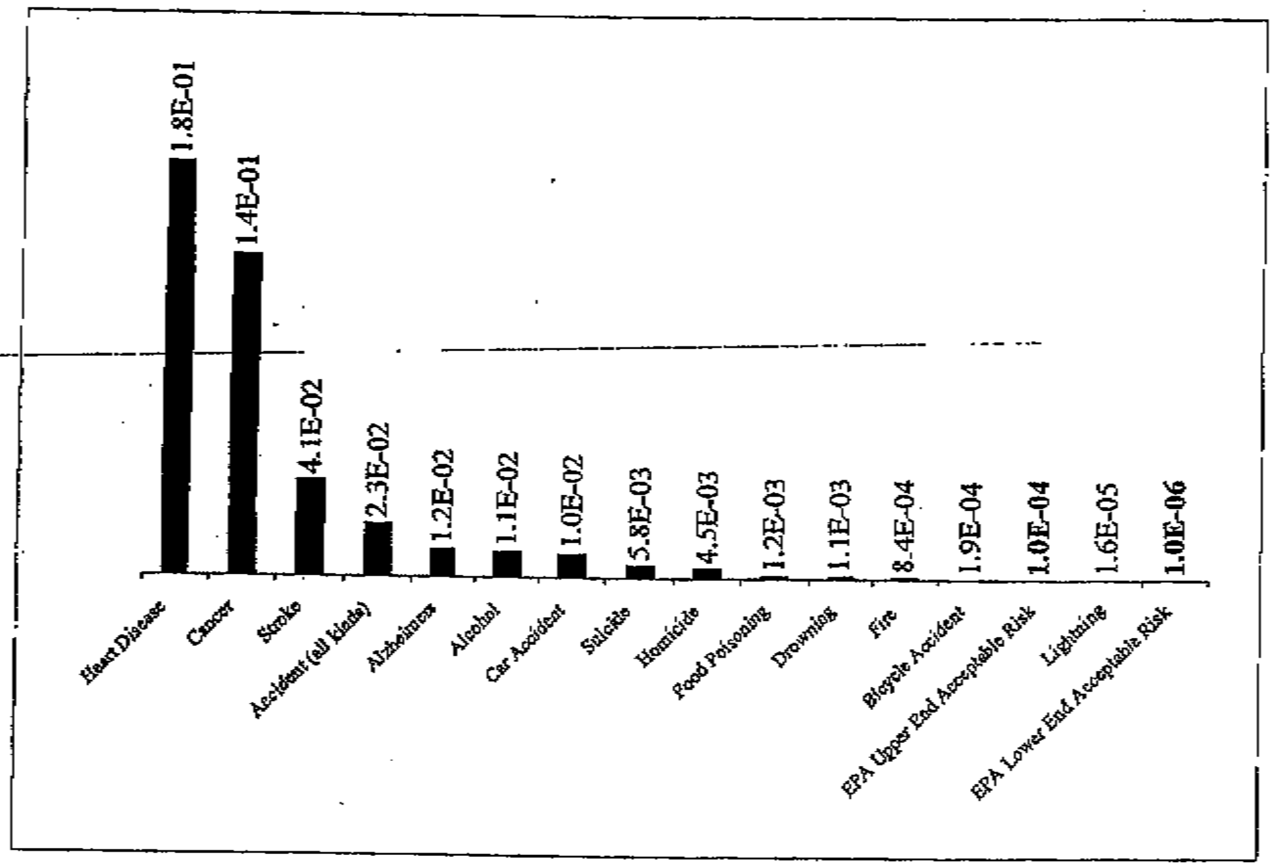
These examples show that the estimated risks associated with VAI are similar or less than risks for common activities in everyday life, and similar to or less than risks of breathing ambient air or drinking tap water.

Table VI-1. Summary of Drinking Water Cancer Risks at the Maximum Contaminant Level Set by EPA

Chemical	MCL	Cancer Slope Factor	Drinking Water Unit Risk	Risk @ MCL, intake 2L/day, 70 kg bw, lifetime exposure
Arsenic	0.010 mg/L *	1.5 per (mg/kg)/day	5×10^{-5} per (µg/L)	4.30E-04
Benzene	0.005 mg/L	1.5×10^{-2} to	4.4×10^{-4} to	2.14E-06
		5.5×10^{-2} per (mg/kg)/day	1.6×10^{-3} per (mg/L)	7.85E-06
Carbon Tetrachloride	0.005 mg/L	1.3×10^{-1} per (mg/kg)/day	3.7×10^{-6} per (µg/L)	1.85E-05
1,2-Dichloroethane	0.005 mg/L	9.1×10^{-2} per (mg/kg)/day	2.6×10^{-6} per (µg/L)	1.30E-05
Vinyl chloride	0.002 mg/L			
Continuous lifetime exposure adulthood				
	LMS method	7.2×10^{-1} per (mg/kg)/day	2.1×10^{-5} per (µg/L)	4.11E-05
	LED 10/Linear	7.5×10^{-1} per (mg/kg)/day	2.1×10^{-5} per (µg/L)	4.28E-05
Continuous lifetime exposure birth				
	LMS method	1.4 per (mg/kg)/day	4.2×10^{-5} per (µg/L)	8.00E-05
	LED 10/Linear	1.5 per (mg/kg)/day	4.2×10^{-5} per (µg/L)	8.57E-05

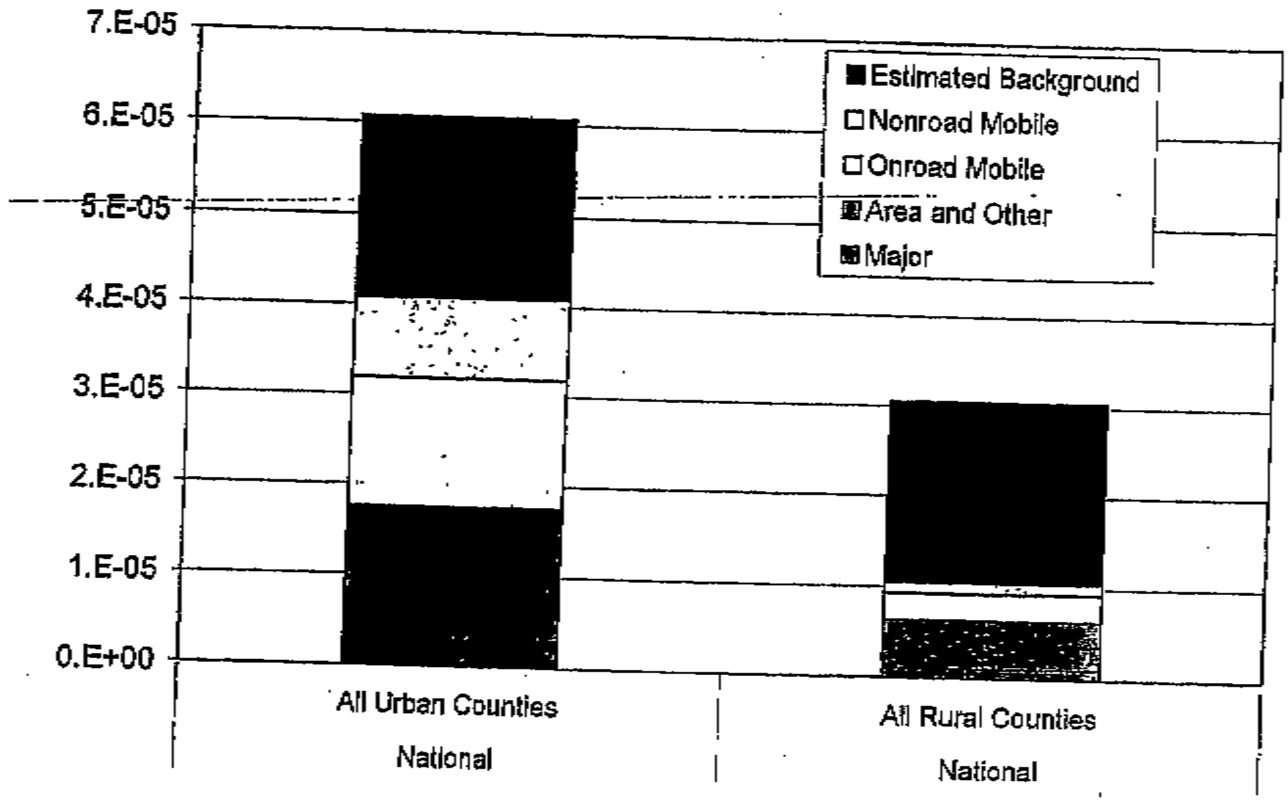
* MCL as of 01/23/06

Figure VI-1. Summary of Estimated Lifetime Mortality Risks for Various Causes



Note: The values in this figure were adapted from data on the Harvard Center for Risk Analysis website: http://www.hcra.harvard.edu/. The risks on the website are on an annual basis, and were multiplied by 70 years to estimate lifetime risks.

Figure VI-2. Summary of Estimated Cancer Risks from Air Pollutants from EPA's National Air Toxics Assessment



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The foregoing represents my opinion to a reasonable degree of scientific certainty.

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